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DEVELOPMENT OF INSTRUCTIONAL MATERIALS FOR A PROCESS-ORIENTED CURRICULUM IN SCIENCE FOR GRADES K-6.

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THE PURPOSE OF THIS STUDY WAS THE DEVELOPMENT OF INSTRUCTIONAL MATERIALS AS PHASE ONE OF THE DEVELOPMENT OF AN INSERVICE TRAINING PROGRAM FOR ELEMENTARY SCHOOL TEACHERS IN THE USE OF A PROCESS APPROACH TO SCIENCE INSTRUCTION. THIS APPROACH ALLOWS THE CHILD TO LEARN THE CONTENT OF SCIENCE KNOWLEDGE THROUGH THE PRACTICE OF SCIENCE BY USING THE SAME PROCESSES OF INVESTIGATION AND DRAWING OF CONCLUSIONS THAT ARE USED BY SCIENTISTS. THE FOUR OBJECTIVES IN THE DEVELOPMENT OF THE INSERVICE TRAINING PROGRAM WERE (1) PREPARATION OF A RATIONALE FOR A PROCESS APPROACH TO SCIENCE INSTRUCTION OF CHILDREN, (2) IDENTIFICATION OF A CONCEPTUAL FRAMEWORK TO GUIDE SELECTION OF SPECIFIC SCIENCE EXPERIENCES FOR CHILDREN, (3) PREPARATION OF INSTRUCTIONAL MATERIALS, AND (4) IDENTIFICATION OF THE SCIENCE BACKGROUND NEEDED BY ELEMENTARY TEACHERS WHO WILL USE THE INSTRUCTIONAL MATERIALS. FULFILLMENT OF THESE OBJECTIVES RESULTED IN COMPLETION OF A SET OF TEXTS FOR GRADES K THROUGH 6 (INCLUDING GUIDE MATERIALS FOR TEACHERS) BASED ON THE ELEMENTARY SCIENCE PROJECT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. THE TEXTS WERE USED IN AN EXPERIMENTAL TRYOUT DURING 1964-65 IN THE PUBLIC SCHOOLS OF AUSTIN, TEXAS. (AL)

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DEVELOPMENT OF INSTRUCTIONAL MATERIALS FOR A PROCESS-ORIENTED CURRICULUM IN SCIENCE FOR GRADES K-6

Cooperative Research Project No. S-081

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The Problem

Cooperating groups of scientists, science educators, administrators, and elementary school teachers have been developing new instructional materials for science in the elementary school. These instructional materials emphasize the processes by which scientific knowledge is obtained as well as the knowledge itself. The instructional materials use the processes of science as the vehicle through which the child studies the body of organized body of science. Through the use of the process approach the child practices science, that is, within his capacities the child uses the same processes of observing, classifying, communicating, predicting, measuring, and drawing inferences as the scientist does when he investigates a problem. The student is not, however, limited to just practicing science for his practice is with science knowledge which has been carefully selected from all science disciplines. Thus, the student understands science in that his classroom experiences helps him establish a framework of knowledge of science which gives the student added direction for his inquiry or practice of science.

Since science is both the product of investigation and the process by which this product has been obtained, the goal of science instruction includes the practice and understanding of science.

Clearly identified goals are essential for instruction. They must be accompanied by instructional materials and teachers who can use these instructional materials effectively. These two tasks are closely realted. Preparation of instructional materials demands that

the writer have clearly identified goals and procedures by which these goals may be translated into student behavior. Effective use of instructional materials also requires that the teacher understands both the goals and the instructional procedure.

To effectively use a process approach to science instruction requires that a teacher have a new frame of reference for her classroom.

One aspect of this frame of reference is the teacher's orientation toward the act of teaching. Rather than seeing how much she can get across to the child, the process approach to science instruction encourages the child to see how much he can get across to the teacher. The responsibility for learning rests on the child and the teacher's function is to provide expert guidance needed by the child for his meaningful explorations.

Another aspect for this frame of reference is the teacher's knowledge of science. The younger the student the less experience he has to direct his exploration in science and the more he needs the guidance of the teacher. To provide this guidance, the teacher needs to know both the essential science content involved in the experiences expected of the student and some depth of knowledge beyond that point.

A third aspect of this frame of reference is the teacher's knowledge and acceptance of a cogent rationale for using a process approach to science instruction. Instructional materials do not provide for every eventuality in the science classroom or laboratory. For a teacher to be effective in capitalizing on daily incidents, she needs to know both

the suggested procedures from the instructional materials and the rationale behind them. She needs to know what she is going to do, how the task is to be done, and why she is doing that way.

In summary, the problem of this study is the identification and description of an in-service training program for teachers who will use a process approach to science instruction. This program included four specific features:

(1) familiarization with new instructional materials

(2) a cogent rationale for using the process approach

(3) the science content background necessary to effectively use a process approach to science instruction

(4) experiences for the teachers in originating, teaching, and evaluating the use of a process approach with children.

Objectives

There were four objectives to the first phase in the development of an in-service training program for the teachers:

(a) preparation of a cogent rationale for the use of a process approach to science instruction with children

(b) identification of a conceptual framework to be used to select the specific science experiences for children in the process-oriented curriculum sequence

(c) identification of the science content background needed by elementary teachers who will use the instructional materials

(d) preparation of the instructional materials designed to illustrate a process approach to the practice and understanding of science.

Related Research

At this point in the science curriculum development in the elementary school, emphasis has been given to the creation and development of curriculum materials and not to the in-service training of teachers. Some examples of the curriculum studies which emphasize the understanding of science include the following:

(a) the Elementary School Science Project at the University of Illinois has been preparing materials in the astronomy for the upper intermediate grades. The assumption is made by this group that what science has taught to children should be soundly correct and should reflect the essential structure of the subject. Within the area of astronomy there are seven basic ideas or themes which comprise its structure. They are: (1) measurement of length and distance, (2) the construction of conceptual models that account for astronomical observations, (3) the physical force of gravitation, (4) the nature of the star, (5) the life story of stars, (6) the structure of our galaxy and the universe of galaxies, (7) cosmology.

(b) The Science Curriculum Improvement Study of the University of California has initiated the development of materials for students in the elementary school. According to project publications, the concepts which embody a scientific point of view are: (1) the concept of interactions between objects as a cause of a phenomena that occurred, (2) the concept of a physical system, (3) the concept of relatively of

motion, (4) the concept of equilibrium, (5) the concept of energy, (6) the concept of force, (7) the concept of entropy, (8) the concept of organic evolution.

(c) The Elementary School Science Project of California. Units of instruction which are based on areas of scientific interests (human physiology, natural selection, and physical chemistry) and which emphasize the content of science disciplines have been developed by the staff of this project.

Other curriculum projects which emphasize the practice of science:

(a) The Educational Services Incorporated Elementary Science Study. Students are premitted to explore some unique and very ingenious materials in an effort to ascertain just what learnings can result. From these explorations, units of instruction have been initiated.

(b) The Science Education Commission of the American Association of the Advancement of Science's Elementary Science Project. From a close look at what a scientist does, behaviors or processes which characterize the investigating scientist have been identified. From a word description of the advanced level of the processes such as observation, classification, and communication, measurement, space-time relationships, inference, or prediction, a sequence of increasingly complex behaviors have been identified. The instructional materials are designed to have students practice these behaviors in a variety of situations with a variety of materials.

Closely related to these curriculum developments are a few research studies dealing with the concept development in children. Of specific importance to the design of instructional materials for children are those studies that give evidence on the degree to which autonomy in the learning situation aids or hinders concept development. Suchman (1960) found that specific training in the practice of science resulted in an increased production of productivity of questions asked, but not in a detectable concept development. Butts (1962) concluded that children of intermediate elementary grades (4, 5, and 6) do not develop concepts when permitted autonomy in their science experiences. He suggested that it seemed logical to conclude that the younger the child, the more direction he needs in his practice of science.

Procedure

Relative to each objective, the following activities were organized.

(1) Description of a rationale and content framework.

Prior to May, 1964, an intensive effort was made to identify for a process approach to science instruction. Using the rationale combined general direction from scientists, teachers, and psychologists, a model of the science curriculum for K-6 was developed which relates the content of science instruction, the way of organizing instruction, and the receptivity of students to instruction. Further work is now needed on the clarification on the terms of the model to aid in its unambiguous communication to teachers why they are using a science process approach. A content framework involved in the understanding of science was identified and submitted to many scientists for thier criticism.

This framework represents the basis for selection of the content of science experiences for students in the intermediate grades. It includes four major themes.

(a) Interconnectedness. For every event there is a probability of interconnectedness with other events. Careful observations indicate the presence of these regularities. Hypotheses are models of them. Experimentation helps verify these models or discredit them.

(b) Matter. The substance of the universe is matter. The combination and arrangements of the elemental structure of matter determines the characteristics of matter. Within matter, we can identify many patterns in this organization. The structure of living things may be defined from our observations in that we see that matter of living things has these levels of organization: environmental, organism, tissue, cell, and molecular.

(c) Energy. Energy is that which makes matter move. Energy is the capacity matter has to change due to its position or motion. It may be described in terms of mechanical, electrical, radiation, and thermal types. The energy of living things can be observed as energy changes in the living organism. Internally, it is the building up and breaking down of the parts of structure. Externally, it is the securing of food or the measure taken to survive. Collectively, the expression of energy is observable in growth and motion of the living organism.

(d) Interdependence. Interactions between matter and matter, energy and energy, matter and energy, represent interdependencies. A dynamic interaction is an equilibrium. Cycles of living and non-living things illustrate interdependencies. Forces are another illustration of interdependencies. For every force, there is an equal force in the opposite direction. If the net forces are zero (no acceleration) matter is either moving at a constant rate or standing still. When the net forces are not zero, (motion), the component forces are not equal and the object is accelerating.

The processes involved in the practice of science were identified as being twelve. In the kindergarten to the third grade, the first eight processes were structured similar to the AAAS Science, A Process Approach. These eight processes are: observation, classification, communication, number relations, space/time relations, measurement, inference, prediction. The additional four processes for the intermediate grade levels are problem definition, verification, model building and experimentation. The rationale, content framework, and processes were then utilized by the teachers in selecting, organizing, and preparing instructional materials for grades K-6.

(2) Identification of science content background.

In the work session, the teachers at the K-3 grade levels reviewed possible curriculum materials for inclusion in the curriculum sequence. Part of the review included the identification of specific portions of science content that were not clear to them. Science consultants were available to assist the teachers with this content background. For the intermediate level teachers the task was somewhat different in that the instructional materials were largely to be original work. In identifying and preparing these exercises, however, the teachers

included a list of science content questions which they felt they would need to know in order to teach the exercise. The answers to these content questions plus other background information which the science consultant felt desirable, were included in the introductory section of each exercise in grades 4, 5, and 6.

(3) The preparation of instructional materials.

To have instructional materials which illustrate a process approach, involved the preceding two activities plus opportunities for the teachers to individually or in small groups prepare and teach the exercises to the other teachers of the same grade level. This "practice" helped identify many ambiguous directions for teachers or suggestions for better ways to involve students in the instructions. The selection, organization, revision, or preparation of the instructional materials for grades K-3 were based primarily on the AAAS, Science, A Process Approach, Part I, II, III, IV, and V. For grades 4, 5, and 6 the materials were largely new. However, the ESI and MINNEMAST materials were helpful. After the three week work session the materials for all seven grades were edited by the project staff and prepared for the 1964-65 school year experimental tryout in the Austin Public Schools with those teachers who participated in the work session.

An outline of the instructional materials for Books K, 1, 2, and 3 include:

(1) objectives - the objectives of the materials are all stated in terms of specific behaviors expected of the children.

(2) rationale - following the objectives of each exercise there is a short rationale in which is described a statement of the relationship of this exercise to the development of inventory of compentencies and knowledges essential for the study of science.

(3) vocabulary - the vocabulary which is anticipated that will be difficult or vocabulary which children might not have been expected to use prior to these exercises is then described. There is no attempt to direct the teacher to specifically teach this vocabulary, but it is suggested that specific emphasis be given to the precision of the use of the words by children.

(4) materials - the materials involved in the teaching of this exercise are then listed.

(5) instructional procedure - the next section describes the instructional procedure. In the instructional procedure an originating of the problem activity is suggested which is then followed by several developmental activities.

(6) appraisal - following the instructional procedure of each exercise, there is an appraisal activity. The appraisal activity exercises are an opportunity for the teacher to see if the specific competencies for which the exercise was designed have been accomplished.

The outline for the Books 4, 5, and 6 are as follows:

(1) pupil behavior - This is a description of the process behavior toward which the exercise is directed.

(2) content theme - This is the theme or part of the conceptual framework which this exercise was chosen to illustrate.

(3) style of instruction - This is a brief description to the teacher of the way in which the class might be organized.

(4) materials - following this section includes a list of the materials used during instruction.

(5) Before you begin - this section is an analysis of the content background which is based on the questions teachers asked and other questions which have been raised concerning the activities of the exercises. Included in this content background is a thumbnail sketch of the exercise which is to follow.

(6) Vocabulary - the vocabulary includes a list of the words and brief definitions which the children are expected to use correctly by the end of this exercise.

(7) Instructional Procedure - instructional procedure includes an originating the problem and specific investigations related to this problem. It also includes two sections; one labeled "student oriented" and one labeled "teacher oriented". Student oriented section deals which the kind of activities that might go on in the classroom. The teacher oriented sections deal with additional background information or further explorations that the teacher might want to introduce.

(8) Summary Activity - the summary activity includes the kinds of activities which might be utilized by the teacher for them to review and pull together the ideas that developed during the exercise.

(9) Behavioral appraisal - For each exercise, an inquiry session is scheduled in order to appraise the students' achievement of the competency and the process identified with the exercise.

The sample of 74 teachers who attended the work-session were selected through the cooperative efforts of the Science Consultant of the Austin

Independent School District and the principals of the eight elementary schools represented at the work session. The criteria for selecting these teachers were:

(1) the teacher was characterized by willingness to be flexible in her approach to science instruction, and

(2) the teacher was expected to remain in Austin for at least the next three years and thus aid the continuity of this study.

While no analysis of the data was anticipated as part of this first phase, the teacher's practice and understanding of science and his attitude toward a process approach to science instruction was sampled by administering three instruments during the early part of the three-weeks work session. These tests included the Sequential Test of Educational Progress, Form 1A, Science, The Tab Inventory of Science Processes, and the EPOC Attitude Inventory. Post test scores on these instruments will be obtained in April, 1965 and appropriate analyses will be made.

Conclusions

One objective of the first phase of this research-development project included the preparation of a rationale for using a process approach to science instruction in the elementary schools. This rationale was well summarized by the teachers who were part of the EPOC summer work session. They referred to a process approach as encouraging the child to see how much he could get across to the teacher rather than the teacher seeing how much she could get across to the child. The teachers described the responsibility for learning as clearly identified with the child and the teacher's responsibility to provide a flexible environment in which the teacher provides stimulating guidance and direction when needed.

Another objective of this first phase of the EPOC Project in Science was the identification of the science content needed by teachers. For each exercise the cooperating teams of teachers in science consultants kept records of the content questions which were raised. These questions and answers were organized into a preliminary section of each exercise entitled "Before You Begin."

A third objective was the selection and preparation of instructional materials which describes a process approach to science instruction. These materials included:

Book	Level	No. of Exercises
K	Kindergarten	23
1	First Grade	33
2	Second Grade	32
3	Third Grade	28
4	Fourth Grade	4
5	Fifth Grade	4
6	Sixth Grade	4

The structure of Books K, 1, 2, and 3 was based on the AAAS Elementary Science Project and the materials for Books 4, 5, and 6 were developed from the interest and ingenuity of the cooperating teams of teachers and science consultants.

Pre-test data on the teachers' practice and understanding of science and their attitude toward a process approach to science instruction in the elementary school were secured. Analysis of this data will be made when the post-test scores are obtained in April, 1965.

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